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EQUIPMENT AND PROCEDURES FOR THE MEASUREMENT OF DEPOSITS OF AERIALLY APPLIED MATERIALS

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The Cover

A dust evaluation test flight being performed over the portable measuring station by a Stearman PT-17 biplane at The Ohio State University airport in Columbus, Ohio.

Equipment and Procedures for the Measurement of Deposits of Aerially Applied Materials

GEORGE S. SANDERS*

INTRODUCTION

In recent years the airplane has come into rather extensive use for the application of materials on agricultural lands and its crops with little information on the basis for equipment design.

Fundamentally, as for ground equipment, the goal for future design should be the deposit of a physically defined material at the required rates on the required surfaces so as to produce the desired results. These standards are defined by agronomists, entomologists, and plant pathologists, but are not being fullfilled by existing equipment.

From a theoretical point of view, the first concern should be the development of a desirable rate of application distribution pattern so as to provide a uniform coverage of particles on the areas to be treated. Because there is a deviation in the intended path of flight due to pilot error in addition to some meterological and topographical factors, it is assumed that it would be impossible to get a uniform coverage if materials were to be deposited in a rectangular pattern, Figure 1. Because of this deviation, there would be uncovered areas in some portions of adjoining swaths as indicated between B and C. A distribution pattern that would overlap would be a more desirable condition since an equal deviation, D, would not leave an untreated area as indicated between B and C, Figure 2. [1] The slope of this overlap should be determined for the mean deviation in future studies.

Grateful acknowledgement is extended to members of the School of Aviation, Ohio State University and members of the Toledo Laboratory U.S.D.A., Toledo, Ohio for their cooperative efforts and council; to the Ohio Aviation Board for their financial assistance; and to William Foster for his valuable assistance with the laboratory experiments.

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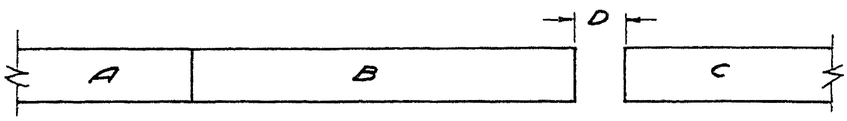


Figure 1. A theorized rectangular deposit distribution pattern showing untreated areas due to a deviation (D) between adjacent swaths.

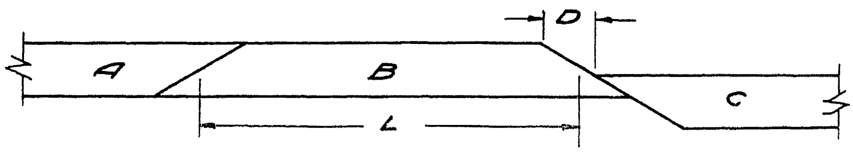


Figure 2. A theorized trapezoidal deposit distribution pattern showing the effect of overlapping on adjoining swaths from an equal deviation (D) of Figure 7.

Based upon the distribution requirements, equipment may be designed and installed within limitations governed by the type of aircraft and air motion surrounding it in flight to approach the required standards. Before the equipment can be evaluated and modified to produce the desired results, some rapid field evaluation devices and procedures must be developed.

In the study reported here, various evaluation and procedure developments are explained. This report is only a phase of an intended comprehensive study on the development of equipment and evaluation processes for agricultural aircraft. Of greater importance is the continuation of studies to provide a common basis for equipment design. It is through this medium that equipment manufacturers will be able to design more adequate equipment that will contribute greatly to the improved performance of agricultural aircraft so as to more closely approach the basic requirements set up by our agricultural scientists.

Objectives of the Study

The primary objective of this study was to develop field evaluation devices and procedures by which deposits of aerially applied dusts, sprays and other materials may be quickly but accurately determined.

In the final analysis this study can be considered a tool or measuring method by which future designs can be determined, evaluated, or modified.

PORTABLE MEASURING STATION

Experimental work of this nature precludes thec ontrolling of influencing variables that contribute little to a particular study. Because of the characteristic methods of application, it became necessary to develop some means of collecting aerially applied materials that would not be affected bya changing wind direction. For this reason a portable collection station was developed. Figure 3. Any stationary collection station must necessarily account for the deviation in the direction of the wind at the time of collection. This movable collection station makes it possible to select any wind direction in any particular study by merely positioning the unit. Under normal conditions, where an evaluation of a particular agricultural aircraft is desired, the unit is placed perpendicular to the direction of the wind and the aircraft is flown upwind and over the center of the station. This procedure minimizes cross wind variables that may easily give unreliable results.

This portable station, Figure 4, is 51 feet in length and contains nine 3-foot in width areas upon which collection pans or trays are placed. Eight additional collection units may be installed in the spaces between them if necessary. The frame of this structure is made from sections of welded steel floor joists that are spaced 3½ feet apart by 1 x 1 inch angle iron. Horizontal deflection is minimized by ⅛ x 1 inch steel straps welded diagonally in the horizontal plane. Vertical rigidity is maintained by 1 x 1 inch angle iron welded diagonally in the vertical plane from one joist to the other. The supporting wheels on the left are mounted on a shaft that is welded to the bottom of the frame.

Below the ends of the 1 x 1 lengths of angle iron, that extend over the side of the measuring station, 1 x 4 inch lumber is bolted. Adding machine paper is attached along this length to provide a visual means of spray deposit evaluation.

After the collection trays or pans have been placed on the portable collection station, the structure may be easily rotated on a radius about the non-castered wheels. A wind direction indicator attached on the station may permit the selection of station position relative to the wind within reasonable limits. Nine collection trays representing 1/5000 of an acre are placed on the station when seeds or fertilizer deposit measurements are desired. These trays are inverted and aluminum pans,

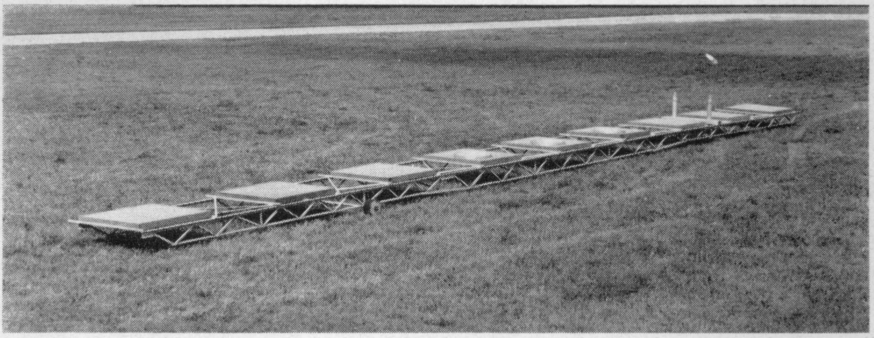


Figure 3. The portable collection station upon which aerially applied materials are collected.

representing 1/20,000 of an acre, are placed upon them when spray or dust deposit measurements are to be made.

COLLECTION AND EVALUATION OF FERTILIZER AND SEED DEPOSITS

Previous investigations at Ohio State University (2) developed collection trays and volumetric measuring tubes for the measurement of fertilizer and seed deposits. The tray, Figure 5, represents a collection area of 1/5000 of an acre and it is approximately 9 square feet in area. 1″ x 4″ yellow pine lumber was used for the frame with a heavy 3 foot waterproff canvas as a bottom. The size of the tray is convenient from the standpoint of size of sample collected and the ease at which calculations can be made.

The measuring tube, Figure 6, was used to determine the application rate deposited on the collection tray. By calculation for five pound per acre increments, the heighth of the calibration holes from the bottom are determined for this 35/64 inch tube. Two tubes were calibrated to include two groupings of commonly used fertilizers. Additional tubes were calibrated for various seed applications.

The trays were placed on the ground at 3-foot intervals and the aircraft flown perpendicular to the line of trays. Materials collected were placed in the calibrated tubes for rate per acre evaluation at each tray position.

In this study, the design of the collection trays were modified, Figure 7 & 8. By calculation, 1/5000 of an acre would be 8.7 square feet or an area approximately 36 inches by 35 inches. The 1″ x 4″ wooden

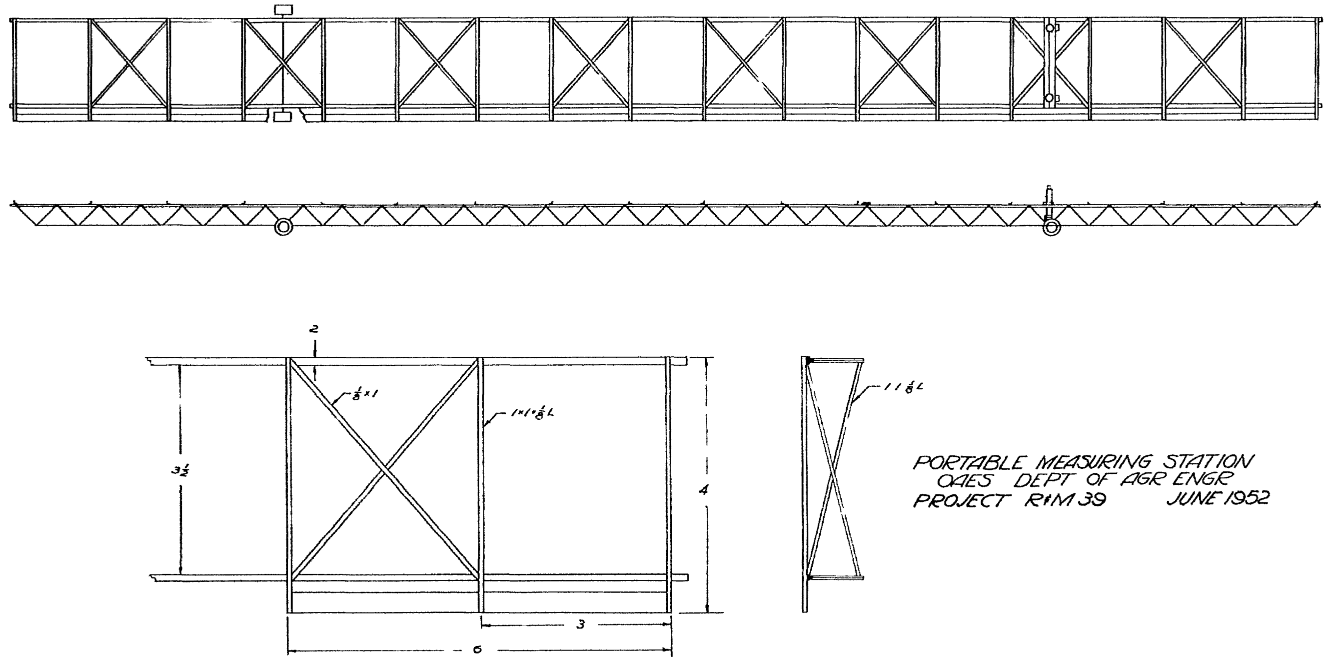


Figure 4. Views and details of construction of the portable collection station.

frame is beveled so as to make the effective inside area 1/5000 of an acre. The plastic bottoms are shaped to allow the material to flow down a hole in the tray and into a calibrated measuring tube or a similar contained beneath.

Where laboratory determinations are desired, the material may be collected in numbered plastic vials, and placed in vial holders, Figure 9.

Because of the large errors encountered in the evaluation of deposits of seeds and fertilizers due to the normal variations in bulk densities within any material, a new type of measuring tube was developed. Its design is based primarily on the bulk density of the material being used. It was developed mathematically as follows:

The application rate times the collection area equals the bulk density of the material in the tube times the volume of material collected.

$$W\,A = D\,a\,X$$

Where
W = application rate (pounds per acre)
A = area of collection tray (acres)
D = bulk density of material in tube
a = cross sectional area of tube
X = height of material in tube

If M is the weight of material in the filled tube and h is the length of the tube, then,

$$D = \frac{M}{ah}$$

Therefore,

$$W\,A = \frac{M}{ah}\,aX$$

or,

$$W\,A = \frac{MX}{h}$$

The collection area was 1/5000 of an acre and the height of the tube was selected to be 12 inches. For convenience the weight of material in the tube was calculated in grams.

Thus

$$\frac{W}{5000} = \frac{M}{453.6} \cdot \frac{X}{12}$$

$$X = \frac{1.09\,W}{M}$$

By using this relationship the size of the tube was not a factor if the weight of the material in a full tube is used in the calculations. However, limitations on the tube size was governed by the quantity of material to be collected. From simple determinations, two diameters were selected, 5/8 and 3/4 inches.

By using the developed formula; the height of the material in the tube was determined for various densities and application rates. Curves were established from the calculations and two types of evaluation tubes are developed, Figures 10 and 11. The first is a reproduction of the density curves on the plastic tube. For any height of material in the tube, a density curve for the particular material will indicate the application rate. The intersection of the density curve and the level of material defines the application rate by a vertical line projected to a horizontal scale. The second method used was the inscribing of horizontal calibrated marks on a plastic tube for each of the various selected densities for application rates from 0 to 200 pounds per acre in increments of 10. The latter method makes interpolation between density curves more difficult.

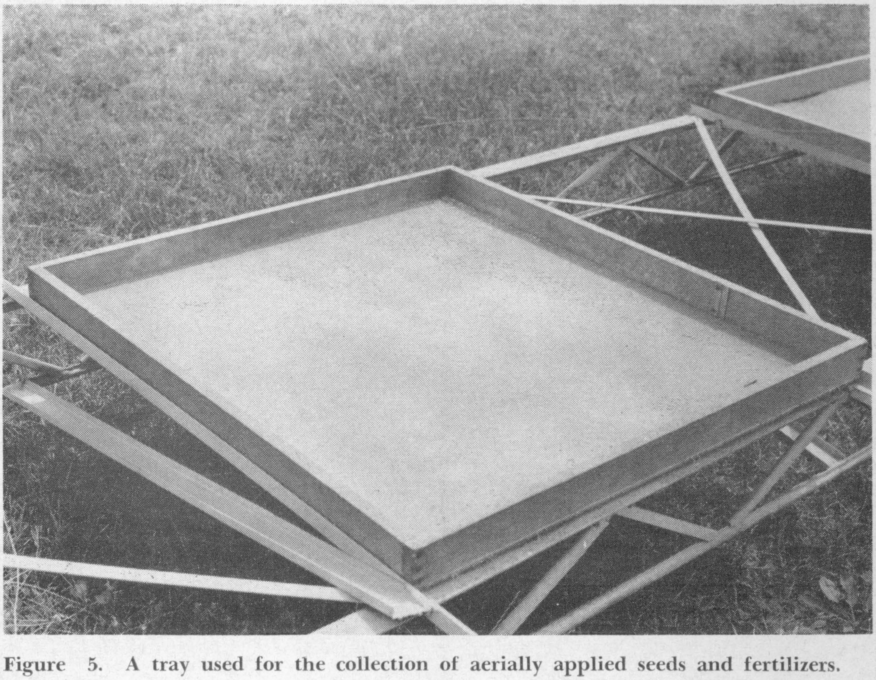


Figure 5. A tray used for the collection of aerially applied seeds and fertilizers.

The net result of this design, based on the actual bulk density of the material in the tube, is the approach to greater accurary in addition to the elimination of the need of many tubes for the various materials collected.

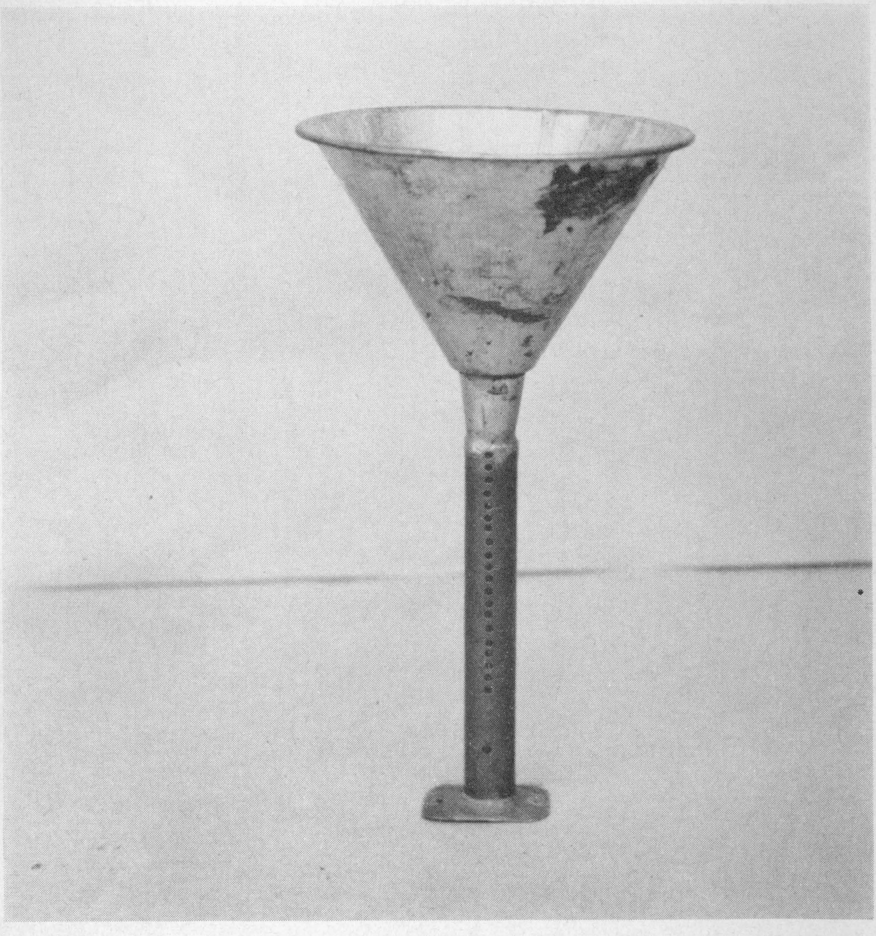


Figure 6. Calibrated measuring tube used to determine the application rate of fertilizers or seeds deposited on the collection tray.

PRELIMINARY EVALUATIONS OF PELETIZED FERTILIZER DEPOSITS

Experiments early in this study were performed to improve the methods and procedures of seed and fertilizer deposit evaluation. By placing the collection units perpendicular to the direction of the wind and flying the aircraft upwind, data were collected and plotted, Figure 12, for various gate openings at the distributing device on the aircraft. The material that was collected in the trays was placed in plastic vials that were numbered for swath position and lettered for gate openings. An accurate gravimetric method was used in the laboratory to determine the application rates for each of the nine samples taken in each

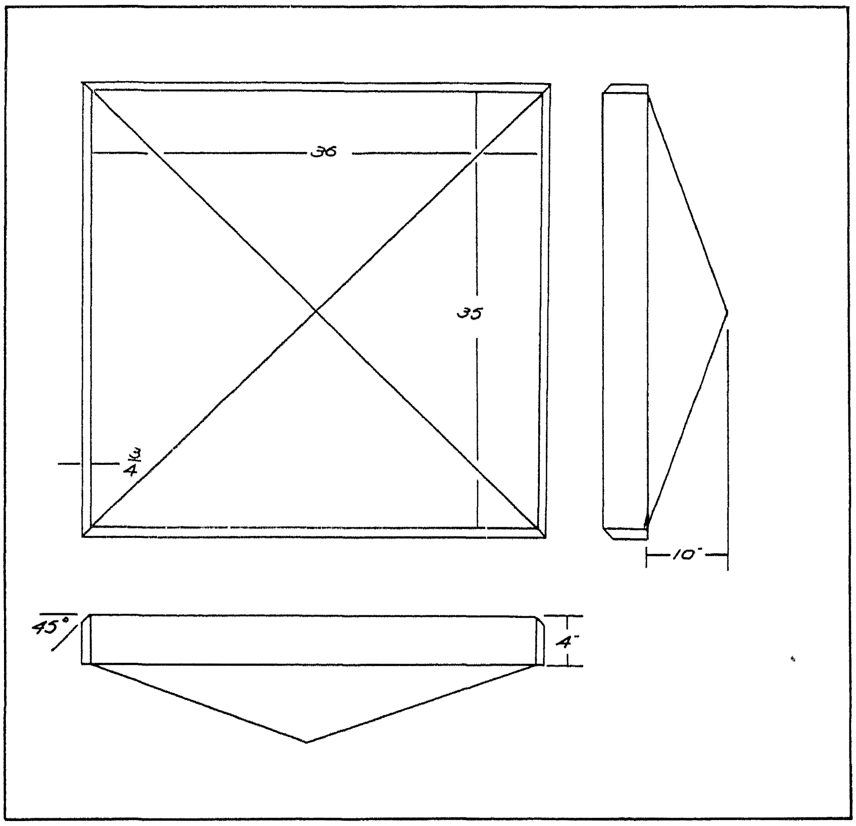


Figure 7. A modified design of the original collection tray permitting the intercepted material to concentrate at its center where it may be more easily handled.

run. Additional tests were performed on each sample of one run to determine the extent at which particle separation took place in the fall to the collection trays.

With the use of the density curve evaluation tube, errors were on the order of five per cent for application rates above 40 pounds per acre with somewhat greater deviations for lower application rates. Greater accuracy is obtained when readings are referred from line just below the top of the material in the tube since the top layer of material is interspaced with voids.

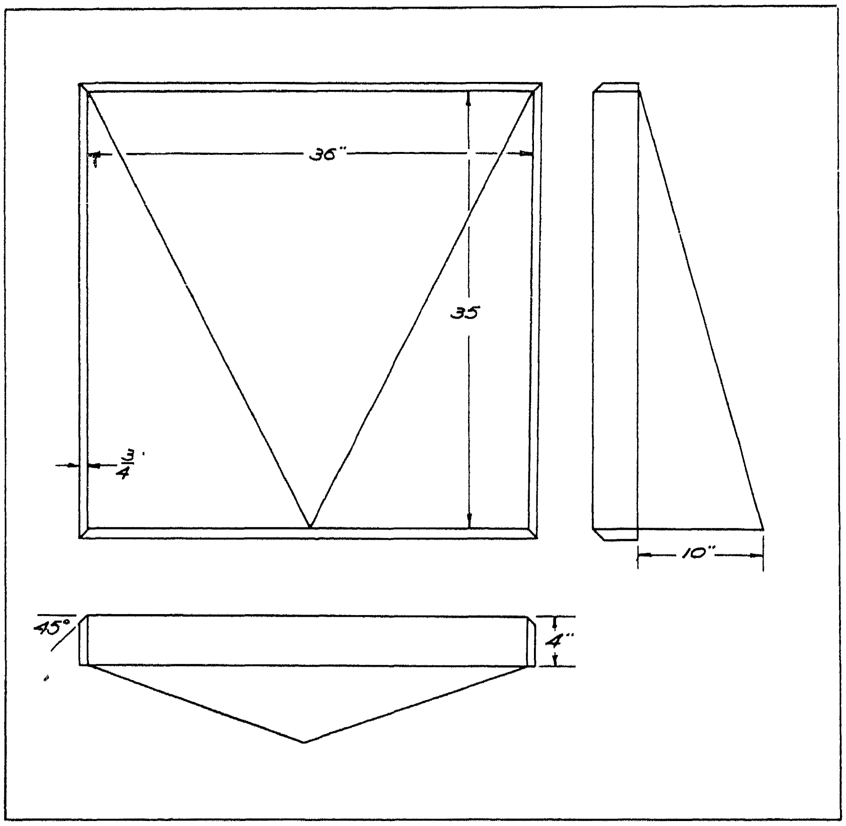


Figure 8. A modified design of the original collection tray permitting the intercepted materials to concentrate at a point at one side where it then may be collected in a calibrated tube from below.

Rapid graphical analysis in the field of any deposit distribution can be made by placing the data upon a large acetate covered rectilinear graph, Figure 13, with a grease pencil.

The effects of modifications on equipment in the field can be visualized more easily by this method than by tabulated data. The grease penciled markings can be easily removed by wiping with a soft cloth.

COLLECTION AND EVALUATION OF DUST DEPOSITS

Quantitative determinations of the rate of application of highly concentrated dusts applied by aircraft presented a difficult problem. The quantity of material applied on a measurable area is so small that the use of a gravimetric or a volumetric method appeared impractical for field use. Of the possible indirect methods, the colorometric determination of trace materials became promising.[3 4] By mixing water

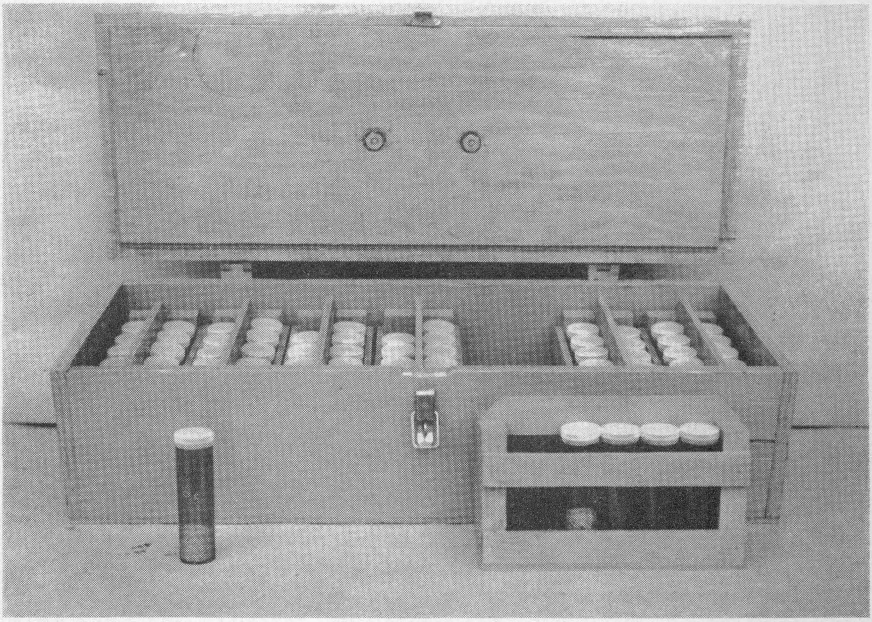
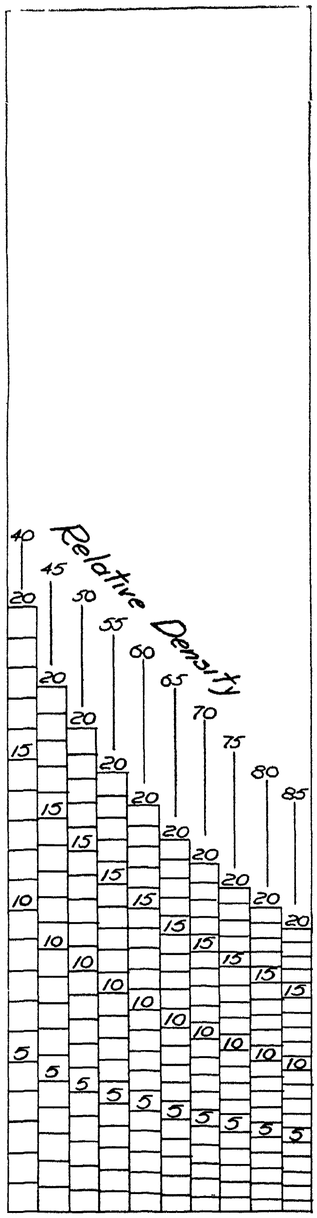


Figure 9. Plastic vials used for containing deposits of seeds or fertilizers collected from the trayas for subsequent laboratory determinations.



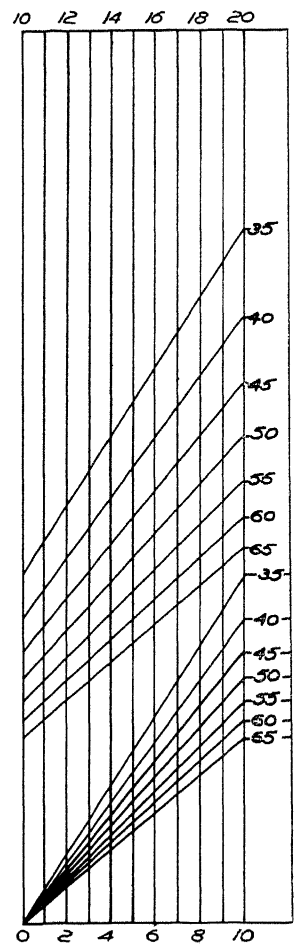


Figure 10. (Right) The density curves that are reproduced on plastic tubes in which application rates may be determined by referring to horizontal scales.

Figure 11. (Left) Illustration of horizontal calibrations of application rates for various indicated densities to be placed on the plastic measuring tube.

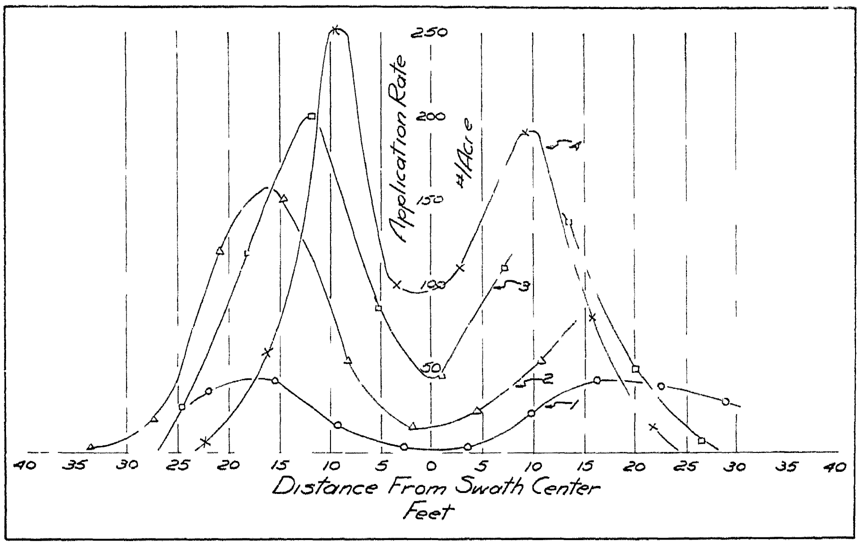


Figure 12. Pelleted fertilizer deposit distribution curves for one, two, three and four inch gate openings from a Stearman biplane.

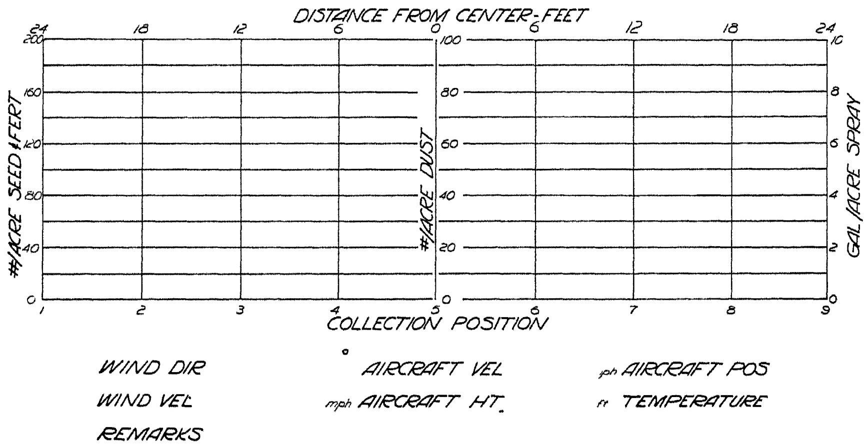


Figure 13. An acetate covered rectilinear graph for evaluating swath distribution patterns in the field. Data are plotted as deposits are measured for spray, dust, or seed and fertilizer runs.

soluable dyes, in fixed ratios, with various dust diluents; a suitable combination evolved and a definite evaluation procedure was established.

Basis for Development

Based upon the anticipated range of deposit rates of dust from one to 100 pounds per acre and the minimum concentration of dye that could be accurately detected by an available photometric instrument; an aluminum pan representing 1/20,000 of an acre was selected as the collecting area, Figure 14. The diameter of the collection pan was calculated to be 20 inches.

At the rate of one pound per acre, it was found that various dyes deposited in the collection pan could be detected in 500 cc of water if the dust to dye ratio by weight was 100:1. A number of suggested dyes were tested in combination with clay, talc, and pyrophyllite. A mechanical mixture of the dyes and diluents proved unsatisfactory

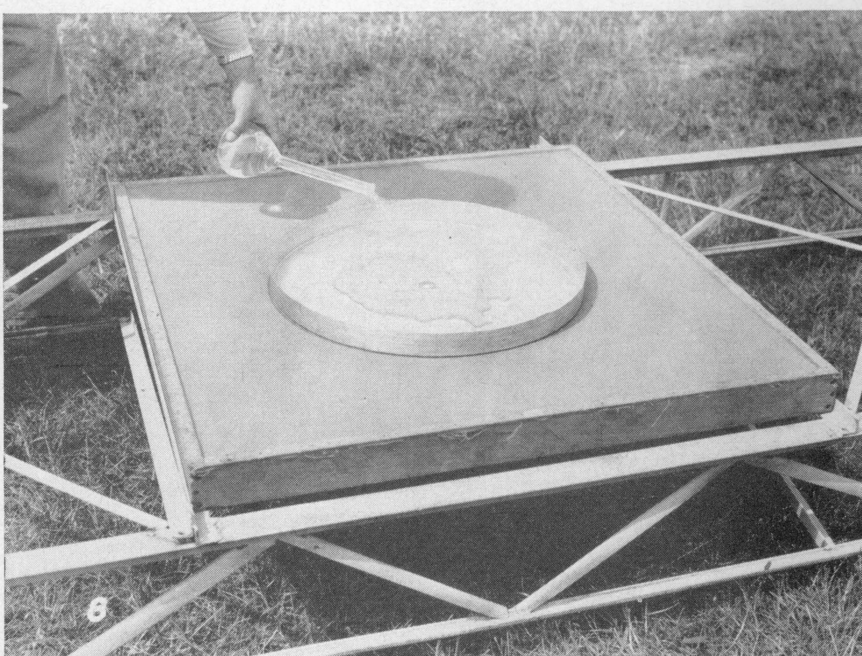


Figure 14. A 20-inch pan spun from sheet aluminum approximates 1/20,000 of an acre and is used for collecting deposits of sprays or dusts.

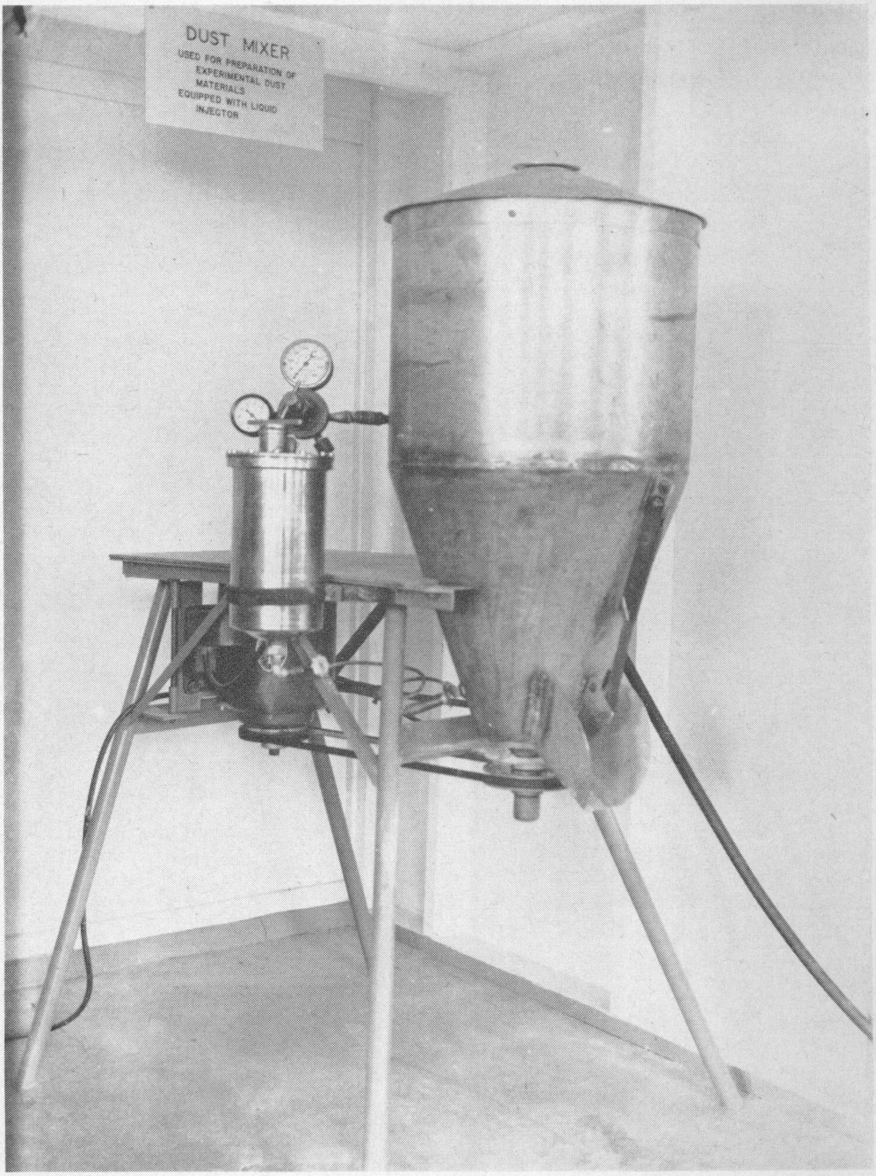


Figure 15. A verticle tube and impeller type dust feeding mechanism used for uniformly impregnataing the dye on the dust diluent.

because of the errors introduced as a result of particle separation. One additional particle of dye beyond the desired ratio could yield a large error in the evaluation of a deposit. Although the use of a slurry proved to be a satisfactory method of combining dye on the dust mass, it too was abandoned because of the equipment and time required to mix, dry, and pulverize the product.

A satisfactory system of impregnating the dust with the dye, came about through the use of a verticle tube and impeller type dust feeding mechanism [5] developed by agricultural engineers of the U.S.D.A. at Toledo, Ohio, Figure 15. The dust is mechanically fluidized as it is impelled from the bottom of the dust tank up through a vertical center tube and back into the tank. In the bottom of the tank, at the greatest point of agitation, a dye solution was sprayed at a slow rate through a small nozzle into the fluidized dust. The rapid cyclic action of the dust aided in causing uniform impregnation of the dust particles by the water-dye solution.

By trial and error, it was found that the maximum quantity of water-dye solution that could be impregnated on insecticide grade pyrophyllite or talc was 500 cc for 100 pounds of the diluent. Additional quantities would cause a paste to be formed and finally, a discontinuation of fluidization and cyclic action would result.

Several attempts were made to impregnate various clays by this method but unfavorable results were experienced. The resulting mixture contained agglomerates of particles with an uneven distribution of the dye.

Experimental Calibration

A dye, used as a tracer in the determination of dust deposits, must meet some rigid specifications. For field use it must be stable in the presence of heat and light. It must be very soluable in water and must be easily removed from diluents upon which it may be absorbed. Uranine C (American Aniline Products, Inc.) was the most satisfactory dye tested.

A typical calibration curve for the determination of dust deposits is illustrated by Figure 16. This curve was constructed by preparing samples of known concentrations, representing actual deposit rates on the collection pan, and then comparing the solutions from these samples with a standard in a photometric instrument.

One of the many photometers available on the market, a six-volt, single photocell filter photometer (E. Leitz, Inc.), was used in this study.

The principle of its operation may be described as follows: A reference cell containing water is placed in the path of a light beam which impinges on a photo-electric cell. The current produced is measured by a low-resistance microammeter and its magnitude is a measure of light intensity transmitted. An identical cell containing the dye solution is now substituted for the reference blank and the intensity of the beam transmitted is measured. The value obtained is the percentage transmittancy if the reference cell reading was adjusted to read 100. In plotting the standard curve, the reference cell is assigned a transmittancy of 100% which represents zero concentration of the constituent. The meter readings from the known concentrations are plotted against the

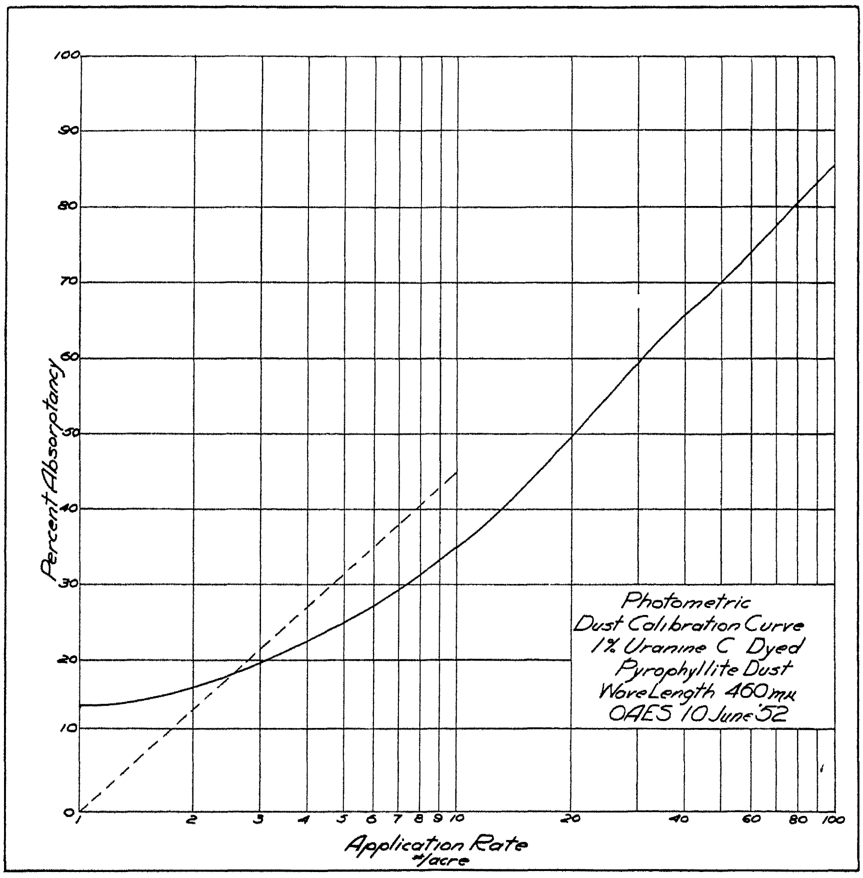


Figure 16. A typical calibration curve for the determination of dust deposits.

concentration, or in this case the application rate represented by the concentration.

Evaluation Procedures

Field procedures for the evaluation of dust deposits have been established as follows, Figure 17, A-E: After the collection pans, Figure 17A, containing 500 cc of water have been placed on the portable measuring station and the station oriented with reference to the wind direction, a dusting test run is made over the center of the station, Figure 17B. After the dust is deposited, the dye on the dust particles desolves in the water to form a yellow green solution. After 10 to 15 seconds, a sample of this solution is transferred into a test tube, Figure 17C, and finally filtered through No. 1 filter paper into an absorption cell, Figure 17D. With the photometer adjusted at 100 by the use of the reference cell, the transmission of light through the absorption cell is measured and recorded, Figure 17E. By the use of the calibration curve,

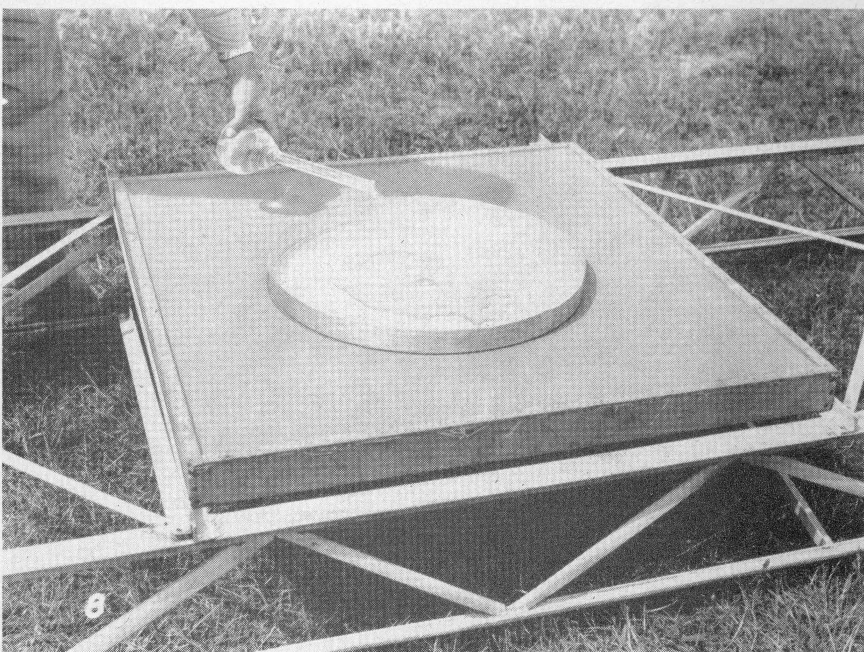


Figure 17A. Water (500 cc) being placed in a 20-inch aluminum collection pan just prior to the dust run.

Figure 16, the rate of application on each pan may be determined from the meter readings when they are subtracted from 100. Again this data may be placed on the field graph. Subsequent dust runs may be made after the collection pans are washed of any remaining dust and dye.

Interpretation of Results

Interpretations of results from the calibrated curve may be inaccurate. An error in reading the dial on the photometer becomes serious when interpretations for rate of application are made on the minimum slopes of the curve. To minimize the chance for error it has been shown that a Relative Analysis Error for a 1 per cent photometric error is given by the following expression. [6]

$$\mathrm{RAE} = \frac{230}{(dI/d)\ \log W}$$

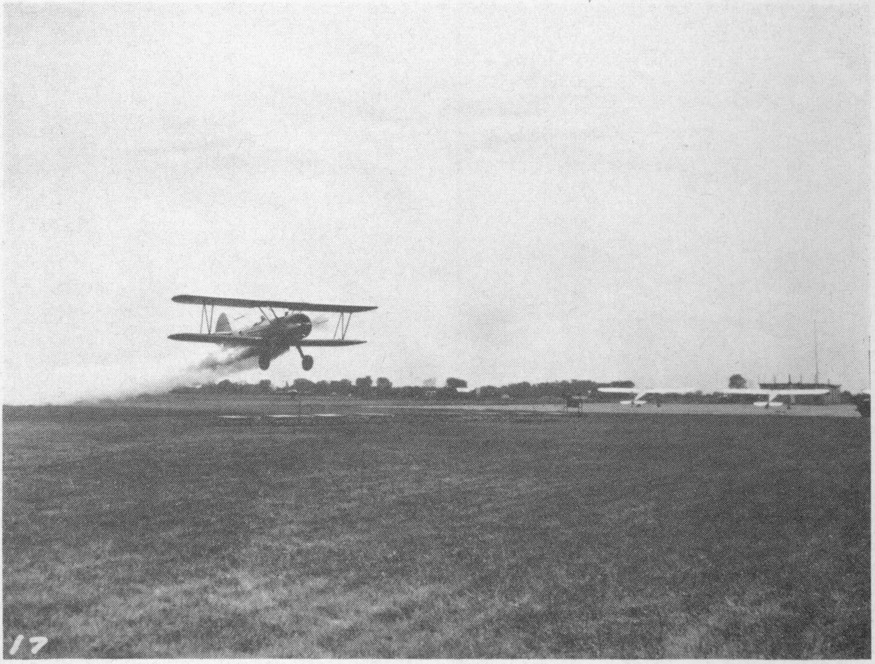


Figure 17B. The dust run being made over the center of the collection station.

Where (dI/d) log W is the slope of the curve at any point in Figure 16. If it is desired that the error not exceed 5 per cent then the minimum slope would be $\frac{230}{5} = 46$. The dotted line drawn across one log cycle and intersecting the ordinate at 46 per cent absorptancy represents the minimum slope of the calibration curve on which the values of application rates are not in error more than 5 per cent. This line transferred to the point of tangency on the curve will indicate a possible error in excess of 5 per cent for rates of application below 10 pounds per acre. To remedy this situation, additional curves may be established by the use of larger or smaller absorption cells or by the proper choice of filter.

COLLECTION AND EVALUATION OF SPRAY DEPOSITS

The problem of rapidly evaluating deposits of aerially applied sprays is similar to dust deposit measurement. The quantity of material that can be collected on a measurable area is not very suitable for gravimetric or volumetric determinations. A variable that complicates direct

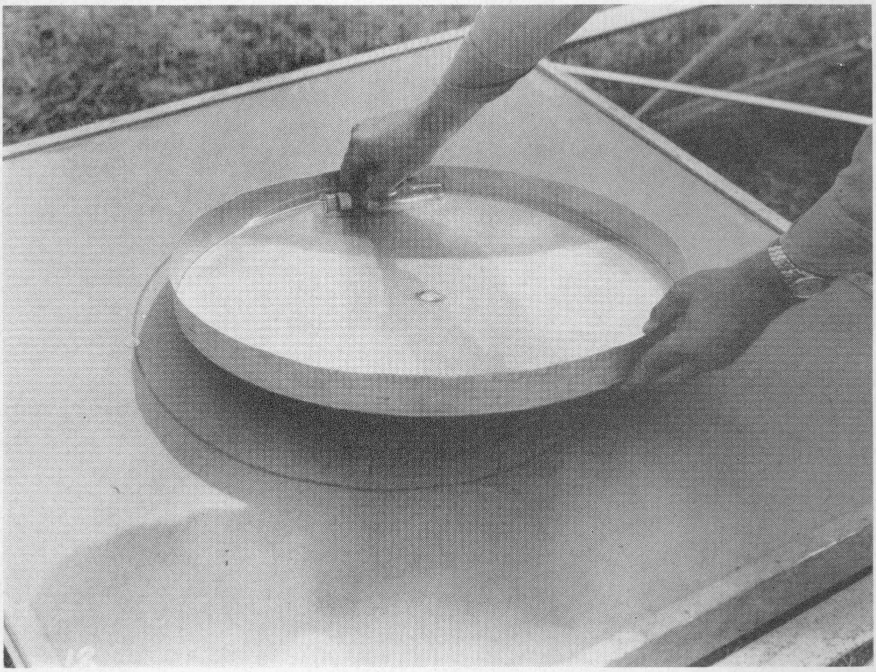


Figure 17C. A sample of the resulting dye solution is transferred to a test tube.

measurement of spray deposits is the loss of liquid by evaporation. However, the use of dye tracers presented a promising measuring method.

Basis for Development

Based upon the anticipated range of application rates of sprays and the desire for simplicity, the dust evaluation pan was also used for

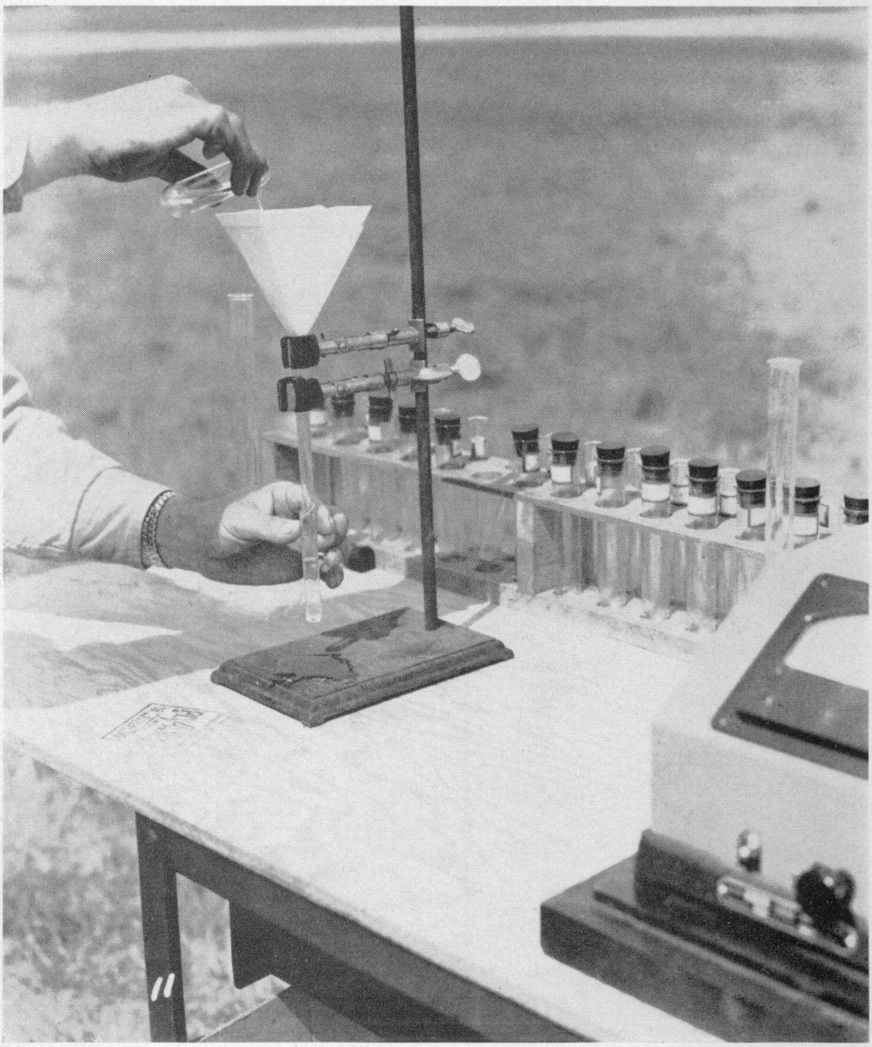


Figure 17D. Samples taken from each collection pan are filtered through No. 1 filter paper into an absorption cell.

spray deposit measurements. By using this collection area it was determined that 46 grams of Uranine C dye (American Aniline Products, Inc.) in one gallon of water was the minimum concentration required to detect liquid application rates from 0.1 to 10 gallons per acre. At this concentration, 2.3 mg. would be collected for each gallon per acre applied.

Figure 17E. **After the photometer is adjusted to indicate 100 by the use of the reference cell, the transmission of light through the absorption cell containing the dyed water is measured and recorded.**

No difficulty was experienced by the use of this highly concentrated dye mixture in aircraft spray tanks. However, several rinsings were necessary to remove the remaining traces of the dye.

Experimental Calibration

Several dyes were tested, and again Uranne C proved to be most satisfactory due to its stability under heat and light and its intense solubility in water.

A typical calibration curve for the determination of spray deposits is illustrated by Figure 18. This curve was constructed by preparing samples of known concentrations, representing actual deposit rates on

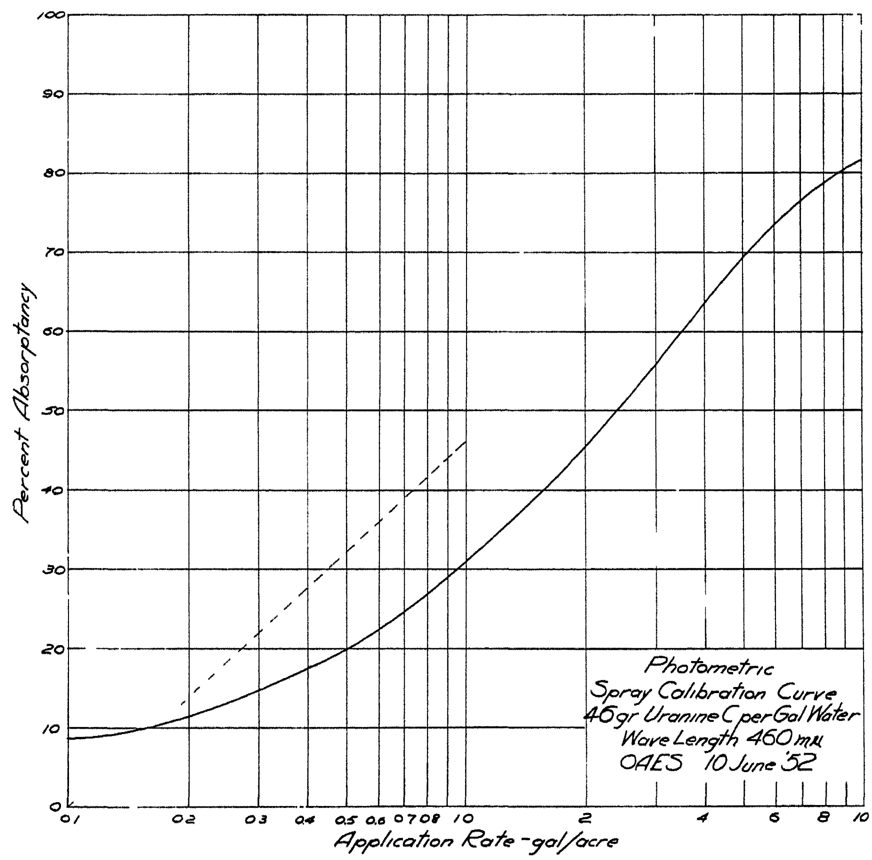


Figure 18. A typical calibration curve for the determination of spray deposits.

the collection pan, and then comparing the solution with a standard in a photemetric instrument.

From a solution of 100 mg. of dye in 1000 cc ol water, samples representing various application rates may be removed and combined with additional water to make 500 cc. The 500 cc samples represent the final dye concentration that will be measured for the construction of the calibration curve. Table 1 below provides the data required to make the calibration of the solution based on a dye concentration of 46 grams of dye per gallon of water.

Evaluation Procedures

Field evaluation procedures have been established as follows, Figure 17A, C, and E: After the collection pans, containing 500 cc of water, Figure 17A, have been placed on the portable measuring station, a spray test run is made over the center of the station. The collected concentrated dye solution will form a yellow-green solution in the water of the pan. A sample of this solution is transferred by a test tube, Figure 17C, to an absorption cell. With reference to a standard cell, the photometric readings for each collected sample are obtained and recorded, Figure 17E. By the use of the calibration curve, Figure 18, the rate of application on each pan may be determined from the meter readings when they are subtracted from 100. These data may be placed on the field graph for instant study. Subsequent tests may be made after the collection pans are washed and rinsed.

TABLE 1.—Volume of Dye Solution Necessary to Represent Various Spray Application Rates in 500 cc Water.

Application Rate (gal/ acre)	Dye Content (mg.)	Volume Required* (cc)
0.1	0.23	2.3
0.2	0.46	4.6
0.5	1.15	11.5
0.7	1.61	16.1
1.0	2.30	23.0
1.4	3.22	32.2
2.0	4.60	46.0
3.0	6.90	69.0
5.0	11.50	115.0
8.0	18.40	184.0
10.0	23.00	230.0

* 100 mg. Uranine C dye in 1000 cc water.

Interpreting Results

The Relative Analyses Error limit is again indicated on the spray calibration curve. The point of tangency is approximately at one gallon per acre. Readings below this application rate indicate a chance for errors greater than 5 per cent for an erroneous meter reading of 1 per cent. Additional curves may be established to remedy this situation by the proper choice of absorption cells and filter.

CONCLUSIONS AND RECOMMENDATIONS

The size of the portable measuring station is adequate in the use for which it was designed. However, the length may easily be extended to include one or two additional measuring areas on both ends. This could be accomplished by constructing hinged, light weight, extensions so that they may be folded over on the main structure when it is being transported.

In conjunction with the use of the measuring station, the installation of a wind direction and velocity indicator becomes necessary. Additional equipment should be installed to aid in determining the horizontal and vertical position of the aircraft over the station because there may be a deviation from the intended path of flight. Further instrumentation can be avoided until future experiments dictate a need.

The modified designs of the trays for the collection of seed or fertilizer deposits provide greater accuracy in the measurements with little time required to transfer the material in the evaluation tubes. With the use of the portable measuring station, the tray with the delivery of the material to one side, appears more advantageous. From the standpoint of ease at which the calibrated measuring tubes may be removed and replaced, this is certainly true.

The design of the calibrated tubes, based on the relative weight of the material in a filled tube, is adequate. However, the problem of transferring the curves on the tube needs to be solved. At any rate, the curves may be printed on a flat acetate sheet and then cemented together to form a cylinder over the measuring tube.

Quantitative determinations of the rates of application of dusts and sprays are defined by the use of dye tracers. The range of measurement may be extended with improved accuracy by the combination of additional dyes. This would require the use of additional filters in the evaluation process.

A significant change in the size of particles was noted as a result of impregnating talc and pyrophyllite with the liquid solution of dye. By an air permeation type determination, it was found that the average particle doubled in size. The results are tabulated in Table 2.

TABLE 2.—Average Particle Size of Dyed and Undyed Talc and Pyrophyllite.

Diluent	Sample	Size (microns)
Pyrophyllite (dyed)	1	10.6
"	2	10.7
"	3	10.9
Pyrophyllite	1	5.4
"	2	5.4
"	3	5.4
Talc (dyed)	1	7.2
"	2	7.1
"	3	7.4
Talc	1	3.7
"	2	3.7
"	3	3.8

The effect of this significant change in particle size on the distribution cannot be determined at this time. If there is a fusion of particles resulting from the addition of dye, it would be difficult to ascertain whether this condition remained after the particles were released. In any event, the evaluation at best is relative and the distribution that is obtained would be similar to the distribution collected with the use of commercial formulations.

The efficiency of collection is another undetermined factor in the evaluation process. Air currents reflected by the design of the collection pans may affect the depositing of dust and spray.

The accuracy of the dust evaluation process may have been in error if the particles of talc and pyrophyllite were not platey in shape. Pyrax ABB is described as "flaky particle shape" in the advertizing literature while Insecticide Grade Pyrophyllite (Glendon Pyrophyllite Co.) is described as "platey or micaceous." A particle size separation does not appear to affect the accuracy of the evaluations since the dye adsorption is a function of the surface area and the mass of the particle is also the function of its surface. This is true for platey material where the variation in particle thickness is not significant. Particle fractionation tests should be performed and evaluations made to remove the doubts of this assumption.

The accuracy of the spray evaluation procedure appears to be very good. Losses due to evaporation do not reflect any losses in the active ingredient of insecticides or fungicides. Therefore, the actual dye deposited accounts for the material that is applied. Both evaluation procedures should be compared with some other accurate but more laborious means.

Accuracy in the spray and dust evaluation procedures is not greatly affected by placing the water in the collection pans before the deposits are made. At a relative humidity of 35% and a temperature of 90 degrees, the percent loss of water for one minute was 0.5%.

The evaluation procedures described in this report provide a convenient method of studying the problems involved in the application of materials by agricultural aircraft. Further efforts could be directed to the use of radioactive materials to tag aerially applied materials. This possibility has been explored through correspondence with the Atomic Energy Commission at Oak Ridge, Tennessee and the indications of success in the measurement of deposits by this means is very promising.

SUMMARY

The field measurement of deposits of dusts, sprays, and other material applied by agricultural aircraft is an important function by which future aircraft equipment designs may be determined, evaluated, and modified. The development of evaluation equipment and procedures for this measurement has been accomplished.

Collection trays for seed and fertilizer evaluation or pans for dust and spray evaluation are placed on a 51-foot, portable measuring station when measurements are to be taken. This welded steel measuring station is constructed to enable collections to be made from any direction. It can be easily rotated about its fixed axle in either direction so as to minimize the effects of cross-winds.

Collection trays representing 1/5000 of an acre are used on the measuring station to collect the desired quantity of fertilizers or seeds for various application rates. The trays are constructed from 1 x 4 inch yellow pine and contain an area 35 inches in width and 36 inches in length. To the bottom of the tray is attached a plastic sheet that slopes

to a collection hole and tube. The collection tube is so designed that the application rate may be determined for various materials that may be used. The basis for its design is development of density curves on the evaluation tube.

Dusts and sprays are collected on pans representing 1/20,000 of an acre. These collection pans are spun from aluminum and are 20 inches in diameter. The dye containing dusts or sprays collected on these pans are combined with 500 cc of water. The relative dye concentration is measured by a photometric instrument and the application rate is determined by comparing the instrument reading with a previously developed calibration curve from known concentrations.

Data established by any one of the evaluation methods may be plotted on a large field graph for immediate study. Based on the changes of deposit distribution that occur as the result of controlled experiments a fund of information will be uncovered. This information may well lead to the development of equipment which gives a distribution pattern that more closely approaches the requirements defined by our agricultural scientists.

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